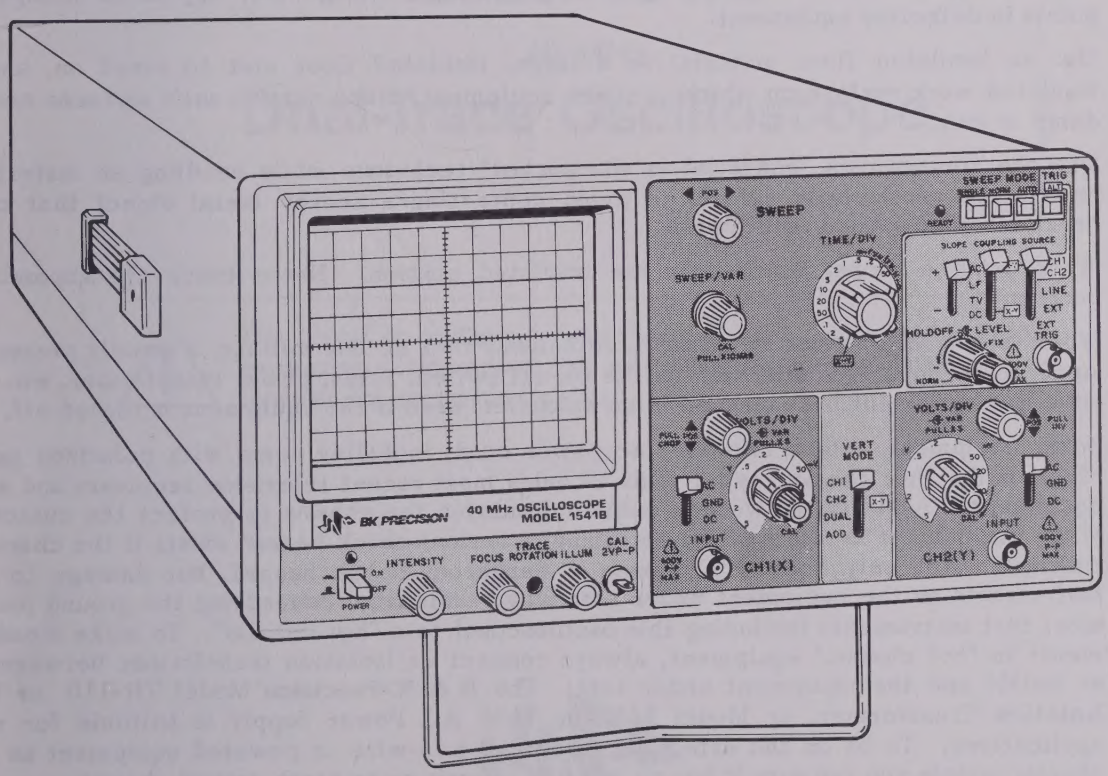
INSTRUCTION MANUAL

BK PRECISION®

MODEL 1541B

40 MHz DUAL-TRACE OSCILLOSCOPE



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TEST INSTRUMENT SAFETY

WARNING

Normal use of test equipment exposes you to a certain amount of danger from electrical shock because testing must often be performed where exposed high voltage is present. An electrical shock causing 10 milliamps of current to pass through the heart will stop most human heartbeats. Voltage as low as 35 volts dc or ac rms should be considered dangerous and hazardous since it can produce a lethal current under certain conditions. Higher voltage poses an even greater threat because such voltage can more easily produce a lethal current. Your normal work habits should include all accepted practices that will prevent contact with exposed high voltage, and that will steer current away from your heart in case of accidental contact with a high voltage. You will significantly reduce the risk factor if you know and observe the following safety precautions:

1. Don't expose high voltage needlessly in the equipment under test. Remove housings and covers only when necessary. Turn off equipment while making test connections in high-voltage circuits. Discharge high-voltage capacitors after removing power.
2. If possible, familiarize yourself with the equipment being tested and the location of its high voltage points. However, remember that high voltage may appear at unexpected points in defective equipment.
3. Use an insulated floor material or a large, insulated floor mat to stand on, and an insulated work surface on which to place equipment; make certain such surfaces are not damp or wet.
4. Use the time-proven "one hand in the pocket" technique while handling an instrument probe. Be particularly careful to avoid contacting a nearby metal object that could provide a good ground return path.
5. When using a probe, touch only the insulated portion. Never touch the exposed tip portion.
6. When testing ac powered equipment, remember that ac line voltage is usually present on some power input circuits such as the on-off switch, fuses, power transformer, etc. any time the equipment is connected to an ac outlet, even if the equipment is turned off.
7. Some equipment with a two-wire ac power cord, including some with polarized power plugs, is the "hot chassis" type. This includes most recent television receivers and audio equipment. A plastic or wooden cabinet insulates the chassis to protect the customer. When the cabinet is removed for servicing, a serious shock hazard exists if the chassis is touched. Not only does this present a dangerous shock hazard, but damage to test instruments or the equipment under test may result from connecting the ground lead of most test instruments (including this oscilloscope) to a "hot chassis". To make measurements in "hot chassis" equipment, always connect an isolation transformer between the ac outlet and the equipment under test. The **B & K-Precision** Model TR-110 or 1604 Isolation Transformer, or Model 1653 or 1655 AC Power Supply is suitable for most applications. To be on the safe side, treat all two-wire ac powered equipment as "hot chassis" unless you are sure it has an isolated chassis or an earth ground chassis.
8. Never work alone. Someone should be nearby to render aid if necessary. Training in CPR (cardio-pulmonary resuscitation) first aid is highly recommended.

Instruction Manual

for

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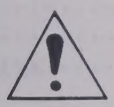
40 MHz

Dual-Trace Oscilloscope



This symbol on oscilloscope means "refer to instruction manual for further precautionary information." This symbol appears in the manual where the corresponding information is given.

BK PRECISION®

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FEATURES

HIGH FREQUENCY FEATURES

Wide Bandwidth
Conservatively rated -3 dB bandwidth is dc to 40 MHz.

Fast Rise Time
Rise time is less than 8.8 ns.

DUAL TRACE FEATURES

Dual Trace

Model 1541B has two vertical input channels for displaying two waveforms simultaneously. Selectable single trace (either CH 1 or CH 2) or dual trace. Alternate or chop sweep selectable at all sweep rates.

Sum and Difference Capability
Permits algebraic addition or subtraction of channel 1 and channel 2 waveforms, displayed as a single trace. Useful for differential voltage and distortion measurements.

CRT FEATURES

Rectangular CRT
Rectangular CRT with large 8 x 10 centimeter viewing area. Internal 8 x 10 division graticule eliminates parallax error.

Convenience
Variable scale illumination for easy viewing in darkened area and for waveform photographs. Trace rotation electrically adjustable from front panel. 0%, 10%, 90%, and 100% markers for rise time measurements.

VERTICAL FEATURES

High Sensitivity
5 mV/div sensitivity for full bandwidth. Selectable X5 gain increases maximum sensitivity to 1 mV/div at reduced bandwidth.

Calibrated Voltage Measurements
Accurate voltage measurements (±3%) on 10 calibrated ranges from 5 mV/div to 5 V/div. Vertical gain fully adjustable between calibrated ranges.

X5 Vertical Gain Magnification
X5 magnification control increases vertical sensitivity and adds 2 mV/div and 1 mV/div calibrated vertical attenuator ranges.

SWEEP FEATURES

Calibrated Time Measurements
Accurate (±3%) time measurements. Model 1541B has 20 calibrated ranges from 0.5 s/div to 0.2 µs/div. Sweep time is fully adjustable between calibrated ranges.

X10 Sweep Magnification
Allows closer examination of waveforms, increases maximum sweep rate to 20 ns/div.

TRIGGERING FEATURES

Five Trigger Modes
Selectable automatic, normal (triggered), FIX, X-Y, or single sweep modes.

AUTO Sweep
Selectable AUTO sweep provides sweep without trigger input, automatically reverts to triggered sweep operation when adequate trigger is applied.

Triggered Sweep
Sweep remains at rest unless adequate trigger signal is applied. Fully adjustable trigger level and (+) or (-) slope.

FIX Trigger Level
Trigger level is automatically fixed on center of waveform.

X-Y Operation
Channel 1 can be applied as horizontal deflection (X-axis) while channel 2 provides vertical deflection (Y-axis).

Single Sweep
Permits viewing and photographing one-time events.

Five Trigger Sources
Five trigger source selections, including ALT, CH 1, CH 2, LINE, and EXT. In ALT, each waveform displayed becomes its own trigger (alternate triggering in ALT dual-trace mode).

Four Trigger Coupling Choices
Selectable AC, LF (high-frequency reject), TV, or DC trigger coupling.

Video Sync
FRAME and LINE triggering automatically selected for observing composite video waveforms.

Variable Holdoff
Trigger inhibit period after end of sweep adjustable. Permits stable observation of complex pulse trains.

OTHER FEATURES

Z Axis Input
Intensity modulation capability permits time or frequency markers to be added. Trace blanks with positive signal, TTL compatible.

Built-In Probe Adjust Square Wave
A 2 V p-p, 1 kHz square wave generator permits probe compensation adjustment.

Channel 1 Output
Buffered 50Ω output of channel 1 signal available on rear panel for driving frequency counter or other instruments. Output is 50 mV/div into 50Ω and at full bandwidth rating.

Supplied With Probes
Oscilloscope comes with two identical 10:1/direct probes.

SPECIFICATIONS

CRT:

Model:
150BYB31.

Type:
Rectangular with internal graticule.

Display Area:
8 x 10 div(1 div = 1 cm).

Accelerating Voltage:
12 kV.

Scale Illumination:
Continuously adjustable.

VERTICAL AMPLIFIERS (CH 1 and CH 2)

Sensitivity:
5 mV/div to 5 V/div.
1 mV/div to 1 V/div, X5 gain selected.

Accuracy:
5 mV/div to 5 V/div, ±3%.
X5 gain selected, ±5%.

Input Resistance:
1 MΩ ±2%.

Input Capacitance:
Approximately 30 pF.

Frequency Response:
5 mV/div to 5 V/div (X5 gain not selected):
DC: DC to 40 MHz (-3 dB).
AC: 10 Hz to 40 MHz (-3 dB).
X5 gain selected:
DC: DC to 20 MHz (-3 dB).
AC: 10 Hz to 20 MHz (-3 dB).

Rise Time:
5 mV/div to 5 V/div (X5 gain not selected):
8.8 ns.
X5 gain selected:
17.5 ns.

Crosstalk:
At least 1000:1 (60 dB) at 50 kHz.
At least 30:1 (31.5 dB) at 40 MHz.

Operating Modes:
CH 1: CH 1, single trace.
CH 2: CH 2, single trace.
DUAL: dual trace.
0.5 s/div to 1 ms/div, CHOP.
0.5 ms/div to 0.2 µs/div, ALT.
CHOP or ALT selectable at any sweep rate.
ADD: algebraic sum of CH 1 + CH 2.

Chop Frequency:
Approximately 250 kHz.

Polarity Reversal:
CH 2 only.

Maximum Input Voltage:
400 V p-p.

HORIZONTAL AMPLIFIER
(Input through channel 1 input)

X-Y mode: switch selectable using front panel controls.
CH 1: X axis.
CH 2: Y axis.

Sensitivity:
Same as vertical channel 1.

Accuracy:
Normal ±4%, X5 Gain ±6%.

Input Impedance:
Same as vertical channel 1.

Frequency Response:
DC to 2 MHz (-3 dB).

X-Y Phase Difference:
3° or less at 50 kHz.

Maximum Input Voltage:
Same as vertical channel 1.

HORIZONTAL AMPLIFIER
(Input through EXT TRIG input)

EXT Horizontal Mode:
Trace swept by external horizontal signal. Vertical axis modes CH 1, CH 2, DUAL, and ADD.

Sensitivity:
Approximately 0.1 V/div.

Bandwidth:
DC to 2 MHz (-3 dB).

Phase Difference:
3° or less at 50 kHz.

Maximum Voltage:
100 V (dc + ac peak) to 1 kHz.

SWEEP SYSTEM

Sweep Speed:
0.2 µs/div to 0.5 s/div in 1-2-5 sequence, 20 steps. Vernier control provides fully adjustable sweep time between steps.

Accuracy:
±3%.

Sweep Magnification:
10X, ±5% (±8% for 0.2 µs/div and 0.5 µs/div).

Linearity (for eight center divisions of sweep):
Norm ±3%.
X10 MAG ±5% (±8% for 0.2 µs/div and 0.5 µs/div).

Holdoff:
Continuously adjustable from NORM to 2 times normal.

TRIGGERING

Trigger Modes:
AUTO (free run), NORM, FIX, X-Y, SINGLE.

Trigger Source:
CH 1, CH 2, ALT, LINE, EXT.

Trigger Coupling:

AC	10 Hz to 40 MHz.
DC	DC to 40 MHz.
LF	10 Hz to 50 kHz.
TV	Line automatically selected at 50 µs/div and faster. Frame automatically selected at 0.1 ms/div and slower.

Trigger Sensitivity:

COUPLING	BANDWIDTH	INT	EXT
DC	DC - 10 MHz DC - 40 MHz	0.5 div 1.5 div	100 mV 200 mV
AC	Same as DC except increased attenuation below 10 Hz		
LF (HF REJ)	Same as AC except increased attenuation above 50 kHz.		
TV		2 div	200 mV
AUTO	Same as AC except lower limit is 50 Hz.		
FIX, ALT	Same as AC plus 0.5 div for signal of duty cycle 20:80 and repetition frequency of 50 Hz to 40 MHz.		

External Trigger:

Input Impedance:
1 MΩ ±2%, approximately 30 pF.

Maximum Input Voltage:
100 V (dc + ac peak) to 1 kHz.

OTHER SPECIFICATIONS

Calibrating Voltage:
1 kHz Positive Square Wave (±5%), 2 V p-p (±2%). Duty cycle of 50% ±2%.

Intensity Modulation:

Input Signal:
TTL level, intensity decreasing with more positive levels.

Input Impedance:
Approximately 5 kΩ.

Usable Frequency Range:
DC to 5 MHz.

Maximum Input Voltage:
100 V (dc + ac peak) to 1 kHz.

CH 1 Output (on rear panel):

Output Voltage:
50 mV/div (into 50-ohm load).

Output Impedance:
Approximately 50 ohms.

Frequency Response:
5 mV/ div to 5 V/div:
100 Hz to 40 MHz, -3 dB, into 50 Ω.
1 mV/div and 2 mV/div:
100 Hz to 15 MHz, -3 dB, into 50 Ω.

Trace Rotation:
Electrical, front panel adjustable.

Power Requirements:
100 V/120 V/220 V/230 V/240 V ±10%, 50/60 Hz, approximately 35 W.

Dimensions:
340 x 145 x 450 mm (12.8 x 6.3 x 17.7").

Weight:
7.4 kg (16.5 lb).

Operating Environment:
+10° to +35° C, 85% maximum relative humidity for full specifications.
0° to +40° C, 85% maximum relative humidity, full operating range.

SUPPLIED ACCESORIES:
Two 10:1 Probes.
Instruction Manual.
Schematic Diagram and Parts List.

OPTIONAL ACCESSORIES:
10:1 Probe, PR-47.
Deluxe 10:1/Direct Probe, PR-37.
100:1 Probe, PR-100.
LC-210 Carrying Case.

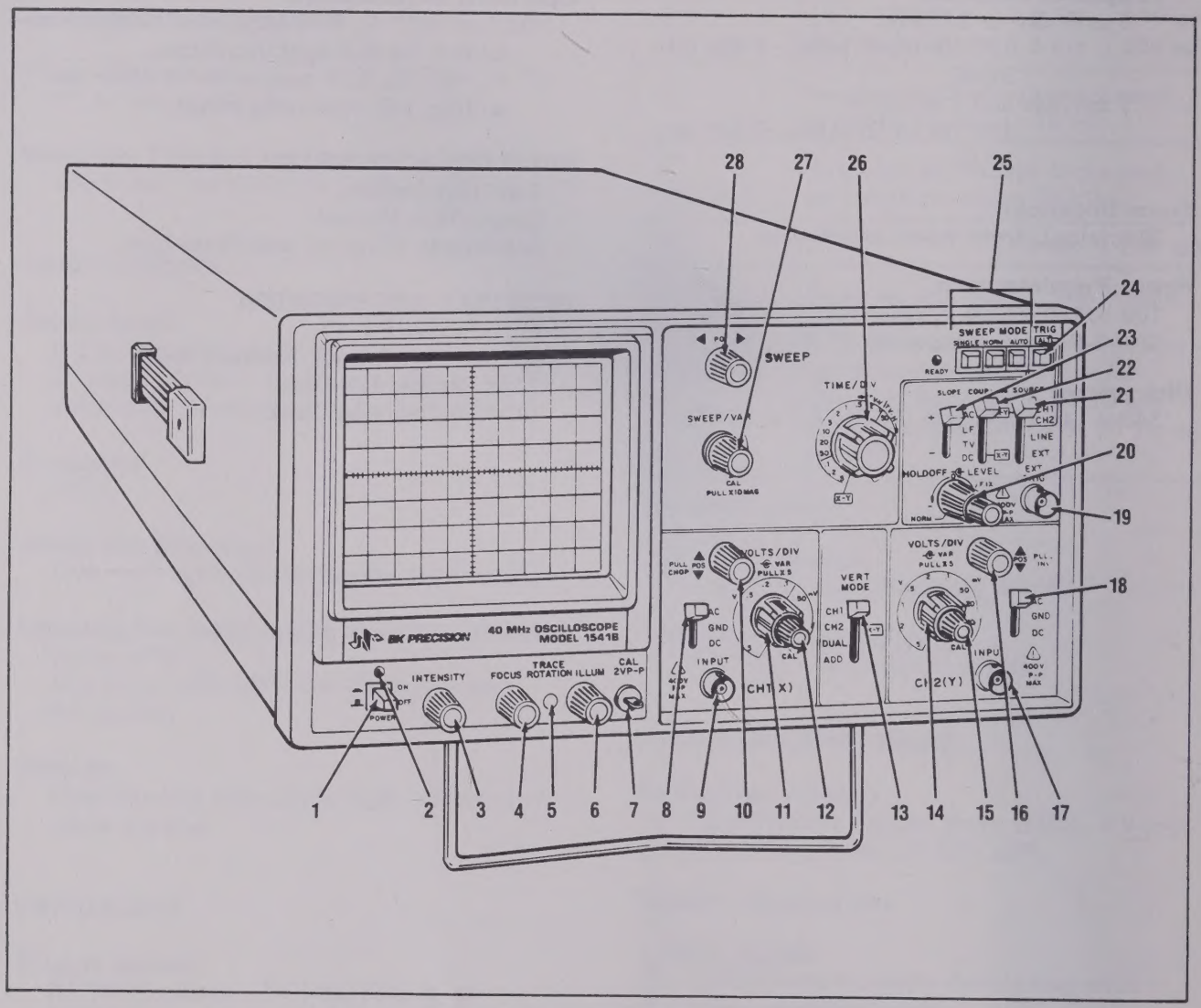


Fig. 1. Front Panel Controls And Indicators.

FRONT PANEL CONTROLS AND INDICATORS

CRT CONTROLS

1. **POWER Switch.** Turns oscilloscope power on and off.

2. **POWER Indicator.** Lights when oscilloscope is on.

3. **INTENSITY Control.** Adjusts brightness of trace.

4. **FOCUS Control.** Adjusts sharpness of trace.

5. **TRACE ROTATION Control.** Screwdriver adjustment used to adjust trace to optimum horizontal position.

6. **Scale ILLUMination Control.** Adjusts intensity of oscilloscope scale. When control is fully counterclockwise, oscillo-

scope scale illumination is off. Clockwise rotation of the control increases the illumination of the graticule scale.

7. **CAL 2 V p-p Terminal.** This terminal provides a 1 kHz, 2-volt peak-to-peak square wave signal. This is useful for probe compensation adjustment and a general check of oscilloscope calibration accuracy.

CHANNEL 1 CONTROLS

8. **AC-GND-DC Switch.** Three-position lever switch which operates as follows:
   AC:
   Channel 1 input signal is capacitively coupled; dc component is blocked.
   GND:
   Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.
   DC:
   Direct coupling of channel 1 input signal; both ac and dc component of signal produce vertical deflection.

9. **CH 1 (X) Jack.** Vertical input for channel 1. X axis input for **X-Y** operation.

10. ▲▼ **CH1 POSition, PULL CHOP Control.**
   ▲▼ **CH 1 POSition:**
   Rotation adjusts vertical position of channel 1 trace.
   PULL CHOP (Push-Pull Switch):
   Selects chop method of dual-trace display. When this control is pulled out and dual-trace is selected, both waveforms will be displayed simultaneously, regardless of **TIME/DIV** or **ALT** control settings. When this control is pushed in and dual-trace is selected, the display method (chop or alternate) is automatically selected by the **TIME/DIV** control (unless overridden by the **ALT** switch).

11. **VOLTS/DIV Control.** Vertical attenuator for channel 1. Provides step adjustment of vertical sensitivity. When channel 1 **VAR** control is set to **CAL**, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 sequence. In **X-Y** operation, this control provides step adjustment of X-axis sensitivity.

12. **VARiable, PULL X5 Control.**
   VARiable:
   Rotation provides vernier adjustment of channel 1 vertical gain. In the fully clockwise (**CAL**) position, the vertical attenuator is calibrated. In **X-Y** operation this control becomes the vernier X-axis gain control.
   PULL X5 (Push-Pull Switch):
   Multiplies channel 1 vertical gain five times; for example, 5 mV/div sensitivity becomes 1 mV/div.

13. **VERTical MODE Switch.**
   CH 1:
   Only the input signal to channel 1 is displayed on the CRT.
   CH 2/X-Y:
   Only the input signal to channel 2 is displayed on the CRT. Also used in conjunction with other controls to select the **X-Y** operating mode. See the "Operating Instructions" for details.
   DUAL:
   The input signals to channel 1 and channel 2 are displayed simultaneously on two traces.
   ADD:
   The inputs from channels 1 and 2 are algebraically summed and displayed as a single signal. When the **CH 2 INV** function is activated, the input from channel 2 is subtracted from channel 1 and the difference is displayed as one signal.

CHANNEL 2 CONTROLS

14. **VOLTS/DIV Control.** Vertical attenuator for channel 2. Provides step adjustment of vertical sensitivity. When channel 2 **VAR** control is set to **CAL**, vertical sensitivity is calibrated in 10 steps from 5 mV/div to 5 V/div in a 1-2-5 se-

quence. In **X-Y** operation, provides step adjustment of Y-axis sensitivity.

15. **VARiable, PULL X5 Control.**
    VARiable:
    Rotation provides vernier adjustment of channel 2 vertical sensitivity. In the fully clockwise (**CAL**) position, the attenuator is calibrated. In **X-Y** operation this control becomes the vernier Y-axis gain control.
    PULL X5 (Push-Pull Switch):
    Multiplies channel 2 vertical gain five times; for example, 5 mV/div sensitivity becomes 1 mV/div.

16. **▲▼ CH2 POSition, PULL INVert Control.**
    ▲▼ CH2 POSition:
    Rotation adjusts vertical position of channel 2 trace. In **X-Y** operation, rotation adjusts vertical position of display.
    PULL INVert (Push-Pull Switch):
    Selects inverse of normal polarity of channel 2 signal; inverted polarity when pulled out, normal polarity when pushed in.

17. **CH 2 (Y) Jack.** Vertical input for channel 2. Y-axis input in **X-Y** operation.

18. **AC-GND-DC Switch.** Three-position lever switch which operates as follows:
    AC:
    Channel 2 input signal is capacitively coupled; dc component is blocked.
    GND:
    Opens signal path and grounds input to vertical amplifier. This provides a zero-volt base line, the position of which can be used as a reference when performing dc measurements.
    DC:
    Direct coupling of channel 2 input signal; both ac and dc component of signal produce vertical deflection.

TRIGGERING CONTROLS

19. **EXT TRIG Jack.** External trigger input for single and dual-trace operation. Also serves as sweep input for external horizontal operation.

20. **Trigger LEVEL, HOLD OFF Control.**
    Trigger LEVEL:
    Trigger level adjustment, determines point on the triggering waveform where the sweep is triggered. Rotation in the (-) direction selects a more negative point of triggering, and rotation in the (+) direction selects a more positive point of triggering. When the control is rotated fully counterclockwise (**FIX**), the **FIX** triggering mode is selected. In this mode, the trigger threshold is automatically set at the center of the waveform.
    HOLD OFF:
    Rotation of control adjusts holdoff time (trigger inhibit period beyond sweep duration). When control is rotated fully counterclockwise, holdoff is set to **NORM.** Holdoff period increases progressively with clockwise rotation to a maximum of about 2 times normal.

21. **Trigger SOURCE Switch.** Selects source of sweep trigger. Four-position lever switch with the following positions:
    CH 1/X-Y:
    Channel 1 signal becomes sweep trigger for dual-trace operation (for single-trace operation, the channel displayed is the trigger signal unless the **LINE** or **EXT** position is selected). Also used in conjunction with other controls to select **X-Y** operating mode. See the "Operating Instructions" for details.
    CH 2:
    Channel 2 signal becomes sweep trigger for dual-trace operation (for single trace operation, the channel displayed is the trigger signal unless the **LINE** or **EXT** position is selected).
    LINE:
    Signal derived from the input line voltage (50/60 Hz) becomes trigger.
    EXT:
    Signal from **EXT TRIG** jack becomes sweep trigger. Also used in conjunction with **TIME/DIV** switch to enable external control of horizontal sweep (via **EXT TRIG** jack).

22. **Trigger COUPLING Switch.** Selects trigger coupling. Four-position lever switch with the following positions:

AC:
Trigger is capacitively coupled; dc component is blocked.

LF:
Trigger is coupled through low pass filter. Frequencies above 40 kHz are attenuated.

TV:
Vertical or horizontal sync pulses are selected. When sweep speeds of 0.1 ms/div or slower are selected, vertical sync pulses are selected. When sweep speeds of 50 µs/div or faster are selected, horizontal sync pulses are selected.

DC/X-Y:
Trigger is direct-coupled, and includes both the ac and dc component. Also used in conjunction with other controls to select **X-Y** operating mode. See the "Operating Instructions".

23. **Trigger SLOPE Switch.** Two-position switch selects negative going or positive going trigger slope. When the switch is in the (+) position, positive going (+) slope is selected and when the switch is in the (-) position, negative-going (-) slope is selected as the triggering point.

24. **ALT TRIG Switch.** Selects alternate trigger and alternate display mode when the switch is engaged and dual-trace display is selected. In the alternate trigger mode, the input signals alternate as the trigger source and triggering is impossible unless both input signals are of adequate level to trigger the sweep. In the alternate display mode when dual-trace display is selected, the waveforms will be displayed in an alternating fashion. However, if the **PULL CHOP** control is in the pulled out position, **CHOP** display mode is selected (the **PULL CHOP** control overrides both the **TIME/DIV** and **ALT** setting) and the display cannot be synchronized since the chopping signal becomes the trigger source.

SWEEP CONTROLS

25. **SWEEP MODE Switches.** Three mechanically interactive switches used to select the desired triggering mode as follows:

AUTO:
Selects automatic triggering mode. Generates sweep (free runs) in absence of trigger; automatically reverts to triggered sweep operation when adequate trigger signal is present.

NORM:
Selects normal triggered sweep operation, which generates a sweep only when adequate trigger signal is present. When the oscilloscope is set up for multiple trigger sources (dual-trace display with **ALT** triggering selected), both channels must have adequate trigger signals to obtain a sweep.

SINGLE:
Selects single sweep operation. For dual-trace display, single sweep requires **CHOP** method of display; do not select **ALT.** A single sweep will begin when the next sync trigger occurs. After a single sweep, **SINGLE** must be pressed again to enable next single sweep. Indicator (**READY** LED) lights to show that single sweep operation is ready for triggering. Lights when **SINGLE** switch is operated and remains lit until one sweep is completed.

26. **TIME/DIV Control.** Provides step selection of sweep rate. When the **SWEEP/VAR** control is set to **CAL**, sweep rate is calibrated. Control has 20 steps from 0.2 µs/div to 0.5 s/div, in a 1-2-5 sequence. This control also enables external control of horizontal sweep, and **X-Y** operating mode. Both functions involve setting other controls in conjunction with **TIME/DIV.** See the "Operating Instructions" for details.

27. **SWEEP/VARiable, PULL X10 MAG Control.**

SWEEP/VARiable.:
Rotation of this control is the vernier adjustment for sweep rate.

When the control is rotated fully clockwise (**CAL**), the sweep rate is calibrated.

PULL X10 MAG (Push-Pull Switch): Selects ten times sweep magnification when pulled out, normal when pushed in. Expands sweep and increases maximum sweep rate to 20 ns/div.

28. **◄► POSition Control.** Horizontal position control. Adjusts horizontal position of display in all operating modes.

REAR PANEL CONTROLS

29. **GND Terminal.** Oscilloscope chassis ground and earth ground via 3-wire ac power cord.

30. **CH 1 OUTPUT Jack.** Output terminal where sample of channel 1 signal is available. Amplitude is 50 millivolts per division of vertical deflection seen on CRT when terminated into 50 ohms. Output impedance is 50 ohms.

31. **Z-AXIS INPUT Jack.** Input jack for intensity modulation of CRT electron beam. TTL compatible (5 volts p-p sensitivity). Positive signal levels decrease intensity.

32. **Fuse Holder/Line Voltage Selector.**

33. **Feet/Cord Wrap.**

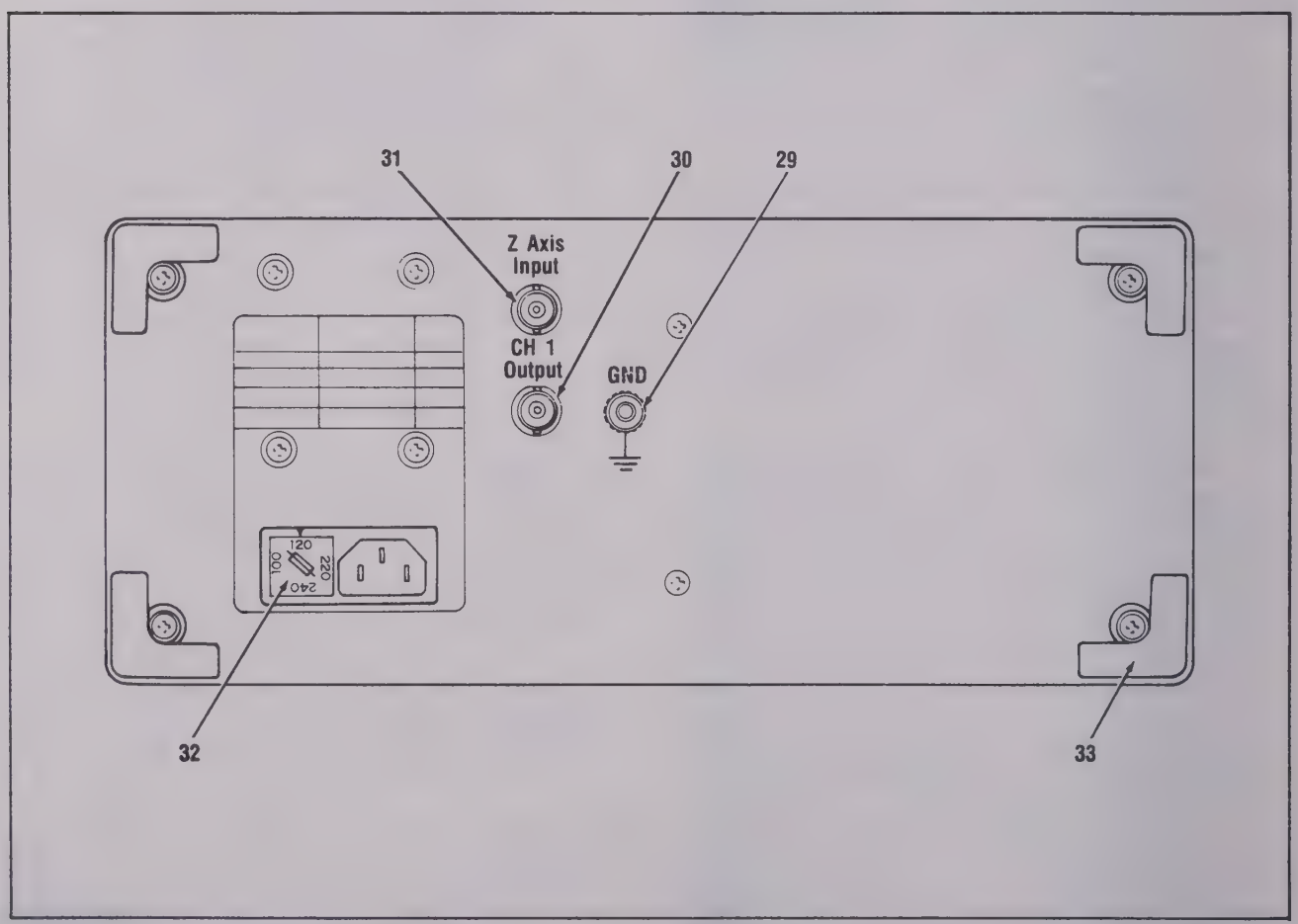


Fig. 2. Rear Panel Controls.

SAFETY PRECAUTIONS

WARNING

The following precautions must be observed to help prevent electric shock.

1. *When the oscilloscope is used to make measurements in equipment that contains high voltage, there is always a certain amount of danger from electrical shock. The person using the oscilloscope in such conditions should be a qualified electronics technician or otherwise trained and qualified to work in such circumstances. Observe the TEST INSTRUMENT SAFETY recommendations listed on the inside front cover of this manual.*

2. *Do not operate this oscilloscope with the case removed unless you are a qualified service technician. High voltage up to 12,000 volts is present when the unit is operating with the case removed.*

3. *The ground wire of the 3-wire ac power plug places the chassis and housing of the oscilloscope at earth ground. Use only a 3-wire outlet, and do not attempt to defeat the ground wire connection or float the oscilloscope; to do so may pose a great safety hazard.*

4. *Special precautions are required to measure or observe line voltage waveforms with any oscilloscope. Use the following procedure:*

   a. *Do not connect the ground clip of the probe to either side of the line. The clip is already at earth ground and touching it to the hot side of the line may "weld" or "disintegrate" the probe tip and cause possible injury, plus possible damage to the scope or probe.*

   b. *Insert the probe tip into one side of the line voltage receptacle, then the other. One side of the receptacle should be "hot" and produce the waveform. The other side of the receptacle is the ac return and no waveform should result.*

EQUIPMENT PROTECTION PRECAUTIONS

CAUTION

The following precautions will help avoid damage to the oscilloscope.

1. Never allow a small spot of high brilliance to remain stationary on the screen for more than a few seconds. The screen may become permanently burned. A spot will occur when the scope is set up for X-Y operation and no signal is applied. Either reduce the intensity so the spot is barely visible, apply signal, or switch back to normal sweep operation. It is also advisable to use low intensity with **AUTO** triggering and no signal applied for long periods. A high intensity trace at the same position could cause a line to become permanantly burned onto the screen.

2. Do not rest objects on top of the oscilloscope or otherwise obstruct the ventilating holes in the case, as this will increase the internal temperature.

3. Excessive voltage applied to the input jacks may damage the oscilloscope. The maximum ratings of the inputs are as follows:

CH 1 and CH 2:
400 V p-p.
EXT TRIG:
100 V dc + ac peak.
Z AXIS INPUT:
50 V dc + ac peak.

Never apply external voltage to oscilloscope output jacks.

4. Always connect a cable from the ground terminal of the oscilloscope to the chassis of the equipment under test. Without this precaution, the entire current for the equipment under test may be drawn through the probe clip leads under certain circumstances. Such conditions could also pose a safety hazard, which the ground cable will prevent.

5. The probe ground clips are at oscilloscope ground and should be connected only to the common of the equipment under test. To measure with respect to any point other than the common, use CH 1 - CH 2 subtract operation (**ADD** mode and **CH 2 INV**), with the channel 1 probe to the point of measurement and the channel 2 probe to the point of reference. Use this method even if the reference point is a dc voltage with no signal.

OPERATING TIPS

The following recommendations will help obtain the best performance from the oscilloscope.

1. Always use the probe ground clips for best results, attached to a circuit ground point near the point of measurement. Do not rely solely on an external ground wire in lieu of the probe ground clips as undesired signals may be induced.

2. Avoid the following operating conditions:
   a. Direct sunlight.
   b. High temperature and humidity.
   c. Mechanical vibration.
   d. Electrical noise and strong magnetic fields, such as near large motors, power supplies, transformers, etc.

3. Occasionally check trace rotation, probe compensation, and calibration accuracy of the oscilloscope using the procedures found in the MAINTENANCE section of this manual.

4. Terminate the output of a signal generator into its characteristic impedance to minimize ringing, especially if the signal has fast edges such as square waves or pulses. For example, the typical 50 Ω output of a square wave generator should be terminated into an external 50 Ω terminating resistor and connected to the oscilloscope with 50 Ω coaxial cable.

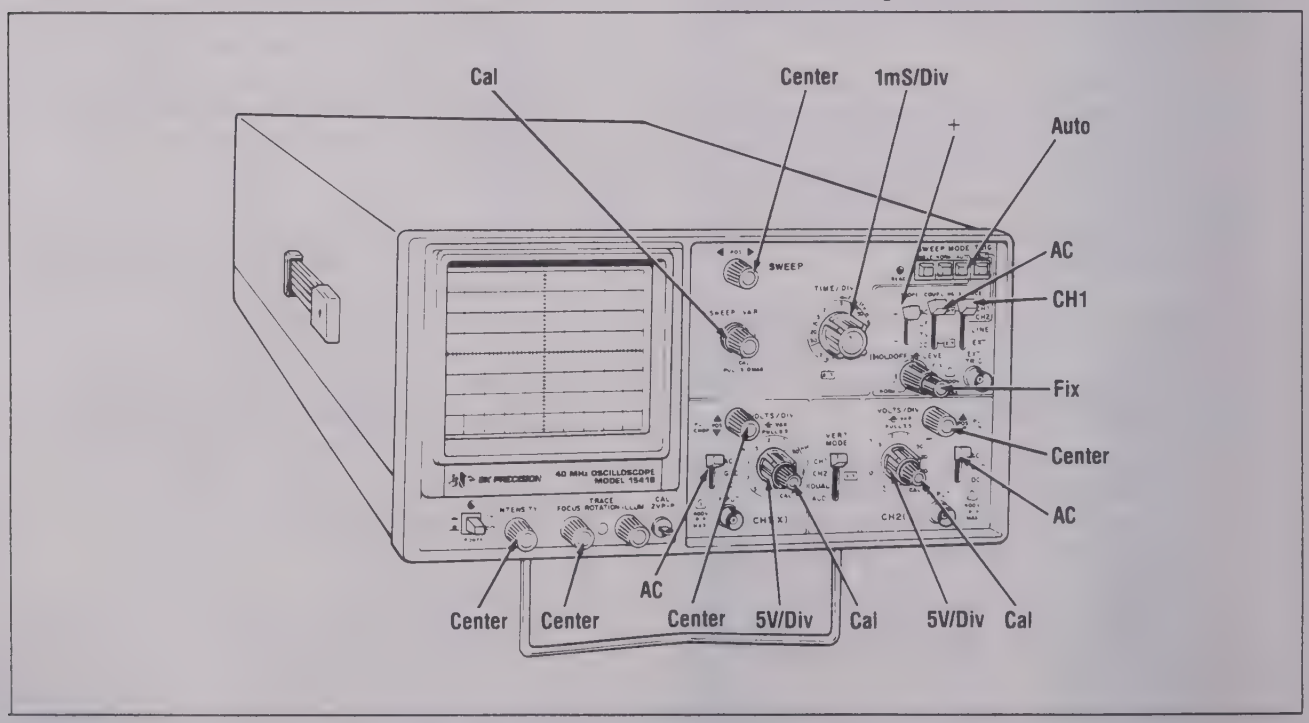


Fig. 3. Initial Control Settings.

5. Probe compensation adjustment matches the probe to the input of the scope. For best results, compensation should be adjusted initially, then the same probe always used with the same channel. Probe compensation should be readjusted when a probe from a different oscilloscope is used.

INITIAL STARTING PROCEDURE

Until you familiarize yourself with the use of all controls, the settings shown in Fig. 3 may be used as a reference point to obtain a trace on the CRT in preparation for waveform observation.

1. Engage the **POWER** switch; the unit will be turned on and the pilot light will be illuminated. Adjust scale illumination level with the **ILLUM** control. When the control is turned fully clockwise, the scale is illuminated at full brightness.

2. Set the controls as indicated in Fig. 3.

3. A trace should appear on the CRT. Adjust the trace brightness with the **INTEN** control and the trace sharpness with the **FOCUS** control.

SINGLE TRACE DISPLAY

Either channel 1 or channel 2 may be used for single-trace operation. The advantage of using channel 2 is that the waveform on the display can be inverted if desired with the **PULL INV** switch.

1. Perform the steps of the "Initial Starting Procedure" with the **VERT MODE** switch set to **CH 2.**

2. Connect the probe to the **CH 2 (Y)** input jack.

3. Connect the probe ground clip to the chassis or common of the equipment under test. Connect the probe tip to the point of measurement.

4. If no waveforms appear, increase the sensitivity by turning the **CH 2 VOLTS/ DIV** control clockwise to a position that gives 2 to 6 divisions vertical deflection.

5. The display on the CRT may be unsynchronized. Refer to the "Triggering" paragraphs in this section for procedures on setting triggering and sweep controls to obtain a stable display showing the desired number of waveforms.

DUAL TRACE DISPLAY

In observing simultaneous waveforms on channel 1 and 2, the waveforms are usually related in frequency, or one of the waveforms is synchronized to the other, although the basic frequencies are different. If the two waveforms have no phase or frequency relationship, there is seldom reason to observe both waveforms simultaneously. However, with **ALT** triggering, two waveforms not related in frequency or period can be simultaneously viewed.

1. Connect probes to both **CH 1 (X)** and **CH 2 (Y)** input jacks.

2. Connect the ground clips of the probes to the chassis or common of the equipment under test. Connect the tips of the probes to the two points in the circuit where waveforms are to be measured.

3. With the **ADD** function selected, the algebraic sum of CH 1 + CH 2 is displayed as a single trace. When the **PULL INV** button is also engaged, the algebraic difference of CH 1 - CH 2 is displayed.

4. To view both waveforms simultaneously, set the **VERT MODE** switch to **DUAL.**

5. When sweep times of 0.5 ms/div and faster are selected, the **ALT** display mode is automatically selected. When sweep times slower than 0.5 ms/div are selected, the **CHOP** display mode is automatically selected. It is possible to override the automatic selection by pulling out the **PULL CHOP** switch to select the **CHOP** display mode at all

sweep speeds or by pressing the **ALT TRIG** switch to select **ALT** display mode at all sweep speeds. However, do not engage **ALT** and **CHOP** display at the same time. Because selecting the **ALT** display mode also selects the **ALT TRIG** mode, selecting both **ALT** and **CHOP** simultaneously results in a display that cannot be synchronized since the chop signal itself becomes the trigger source. Use the **ALT** mode only, or select a trigger source of channel 1 or channel 2.

a. In the **ALT** mode, one sweep displays the channel 1 signal and the next sweep displays the channel 2 signal in an alternating sequence. Alternate sweep is normally used for viewing high-frequency or high-speed waveforms at sweep times of 1 ms/div and faster, but may be selected at any sweep time.

b. In the **CHOP** mode, the sweep is chopped at an approximate 250 kHz rate and switched between channel 1 and channel 2. Chop sweep is normally used for low-frequency or low-speed waveforms at sweep times of 1 ms/div and slower. If chop sweep is used at sweep times of 0.2 ms/div and faster, the chop rate becomes a significant portion of the sweep and may become visible in the displayed waveform. However, you may select chop sweep at any sweep time for special applications. For example, the only way to observe simultaneous events on a dual-trace scope at any sweep rate is with chop sweep.

6. Adjust the **CH 1** and **CH 2 POS** controls to place the channel 1 trace above the channel 2 trace.

7. Set the **CH 1** and **CH 2 VOLTS/DIV** controls to a position that gives 2 to 3 divisions of vertical deflection for each trace. If the display on the screen is unsynchronized, refer to the "Triggering" paragraphs in this section of the manual for procedures for setting triggering and sweep time controls to obtain a stable display showing the desired number of waveforms.

TRIGGERING

The Model 1541B Oscilloscope provides versatility in sync triggering for ability to obtain a stable, jitter-free display in single-trace, or dual-trace operation. The proper settings depend upon the type of waveforms being observed and the type of measurement desired. An explanation of the various controls which affect synchronization is given to help you select the proper setting over a wide range of conditions.

SWEEP MODE Switches

1. The **NORM** switch provides normal triggered sweep operation. The sweep remains at rest until the selected trigger source signal crosses the threshold level set by the **TRIG LEVEL** control. The trigger causes one sweep to be generated, after which the sweep again remains at rest until triggered. In the **NORM** position, there will be no trace unless an adequate trigger signal is present. In the **ALT** mode of dual trace operation with **NORM** sweep selected, there will be no trace unless both channel 1 and channel 2 signals are adequate for triggering. Typically, signals that produce even 1/2 division of vertical deflection are adequate for normal triggered sweep operation.

2. When the **AUTO** switch is engaged, automatic sweep operation is selected. In automatic sweep operation, the sweep generator free runs to generate a sweep without a trigger signal. However, it automatically switches to triggered sweep operation if an acceptable trigger source signal is present. The **AUTO** position is handy when first setting up the scope to observe a waveform; it provides sweep for waveform observation until other controls can be properly set. Once the controls are set, operation is often switched back to the **NORM** triggering

mode, since it is more sensitive. Automatic sweep must be used for dc measurements and signals of such low amplitude that they will not trigger the sweep.

NOTE

In the **X-Y** mode, the sweep generator and triggering circuits are disconnected and have no effect.

Trigger SOURCE Switch

The trigger **SOURCE** switch **CH 1, CH 2,** etc.) selects the signal to be used as the sync trigger. In the single trace display mode (**VERT MODE** set to either **CH 1** or **CH 2**), the channel selected for display is automatically selected as the trigger source unless the trigger **SOURCE** switch is set to the **LINE** or **EXT** position.

1. If the **SOURCE** switch is set to **CH 1** (or **CH 2**) the channel 1 (or channel 2) signal becomes the trigger source when **DUAL** or **ADD VERT MODE** is selected. **CH 1**, or **CH 2** is often used as the trigger source for phase or timing comparison measurements.

2. If the **SOURCE** switch is set to the **LINE** position, triggering is derived from the input line voltage (50/60 Hz). This is useful for measurements that are related to line frequency.

3. If the **SOURCE** switch is set to the **EXT** position, the signal applied to the **EXT TRIG** jack becomes the trigger source. This signal must have a timing relationship to the displayed waveform(s) for a synchronized display.

ALT TRIG Switch

The **ALT TRIG** switch is used to select alternate triggering and alternate display when the **DUAL**-trace **VERT MODE** is selected (the switch has no effect in the **CH 1, CH 2,** or **ADD** modes). In the alternate triggering mode (when dual-trace operation is selected), the trigger source alternates between channel 1 and channel 2 with each sweep. This is convenient for checking amplitudes, waveshape, or waveform period measurements, and even permits simultaneous observation of two waveforms which are not related in frequency or period. However, this setting is not suitable for phase or timing comparison measurements. For such measurements, both traces must be triggered by the same sync signal.

When the **PULL CHOP** and the **ALT TRIG** switches are both engaged during dual-trace operation, synchronization of the display is not possible because the chopping signal becomes the trigger. Use the **ALT** mode by itself, or select **CH 1** or **CH 2** as the trigger source.

Trigger LEVEL and SLOPE Controls
(Refer to Fig. 4)

A sweep trigger is developed when the trigger source signal crosses a preset threshold level. Rotation of the trigger **LEVEL** control varies the threshold level. In the + direction, the triggering threshold shifts to a more positive value, and in the - direction, the triggering threshold shifts to a more negative value. When the control is centered, the threshold level is set at the approximate average of the signal used as the triggering source. Rotating the control fully counterclockwise past the click stop, selects the **FIX** trigger mode. In the **FIX** mode, the trigger point is automatically set at the center of the waveform. Proper adjustment of this control usually synchronizes the display.

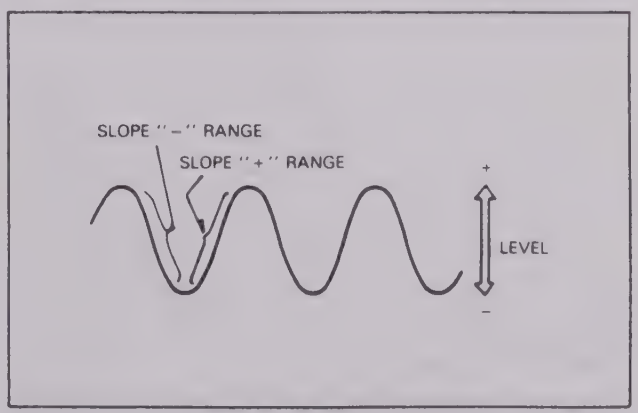


Fig. 4. Function of Slope and Level Controls.

The trigger **LEVEL** control adjusts the start of the sweep to almost any desired point on a waveform. On sine wave signals, the phase at which sweep begins is variable. Note that if the **LEVEL** control is rotated toward its extreme + or - setting, no sweep will be developed in the **NORM** trigger mode because the

triggering threshold exceeds the peak amplitude of the sync signal.

When the trigger **SLOPE** control is set to the (+) position (up), the sweep is developed from the trigger source waveform as it crosses the threshold level in a positive-going direction. When the **SLOPE** control is set to the (-) position (down), a sweep trigger is developed from the trigger source waveform as it crosses the threshold level in a negative-going direction.

Trigger COUPLING Switch

1. Use the **AC** position for viewing most types of waveforms. The trigger signal is capacitively coupled and may be used for all signals from 10 Hz to 40 MHz.

2. Use the **LF** position to eliminate high frequency components for stable triggering of low frequency signals.

3. The **TV** position is primarily for viewing composite video waveforms. A sync separator circuit separates sync pulses from video. Vertical sync pulses are selected as trigger when sweep speeds of 0.1 ms/div and slower are selected (**TV V**) and horizontal sync pulses are selected as trigger when sweep speeds of 50 µs/div and faster are selected (**TV H**). The **SLOPE** switch should be set according to the type of video signal (i.e., if the video signal has negative sync pulses, the **SLOPE** switch should be set to the (-) position. Additional procedures for observing video waveforms are given later in this section of the manual.

4. The **DC** position should be used when it is desirable to include the triggering effects of the dc component.

TIME/DIV Control

Set the **TIME/DIV** control to display the desired number of cycles of the waveform. If there are too many cycles displayed for good resolution, switch to a faster sweep speed. If only a line is displayed, try a slower sweep speed. When the sweep speed is faster than the waveform being observed, only part of it will be displayed, which may appear as a straight line for a square wave or pulse waveform.

HOLDOFF Control
(Refer to Fig. 5)

A "holdoff" period occurs immediately after the completion of each sweep, and is a period during which triggering of the next sweep is inhibited. The normal holdoff period varies with the sweep rate, but is adequate to assure complete retrace and stablization before the next sweep trigger is permitted. The **HOLDOFF** control allows this period to be extended by a variable amount if desired.

This control is usually set to the **NORM** position (fully counterclockwise) because no additional holdoff period is necessary. The **HOLDOFF** control is useful when a complex series of pulses appear periodically, such as in Fig. 5A. Improper sync may produce a double image as in Fig. 5B. Such a display could be synchronized with the **SWEEP/VAR** control, but this is impractical because time measurements are then uncalibrated. An alternate method of synchronizing the display is with the **HOLDOFF** control. The sweep speed remains the same, but the triggering of the next sweep is "held off" by the duration selected by the **HOLDOFF** control. Turn the **HOLDOFF** control clockwise from the **NORM** position until the sweep starts at the same point of the waveform each time. Maximum setting (turned fully clockwise) is 2 times greater than at the **NORM** setting.

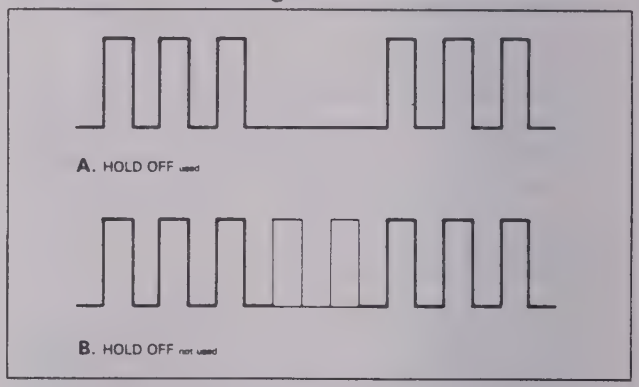


Fig. 5. Use of HOLDOFF control.

SINGLE SWEEP

This mode of display is useful for looking at non-synchronous or one time events.

1. Select either the **AUTO** or **NORM SWEEP MODE.** Apply a signal of approx-

imately the same amplitude and frequency as the signal that is to be observed as the trigger signal and set the trigger level.

2. Press and release the **SINGLE SWEEP MODE** switch (it will return to the disengaged position), make sure that the **READY** LED lights to indicate the reset condition. This LED goes out when the sweep period is completed.

3. The scope is now ready to operate in the **SINGLE** sweep mode of operation. Input of the trigger signal results in one and only one sweep.

NOTE

For dual-trace operation simultaneous observation is not possible using the **ALT** mode. Set the unit to the **CHOP** mode in this case.

X-Y OPERATION

X-Y operation permits the oscilloscope to perform many measurements not possible with conventional sweep operation. The CRT display becomes an electronic graph of two instantaneous voltages. The display may be a direct comparison of the two voltages such as a vectorscope display of video color bar patterns. However, the **X-Y** mode can be used to graph almost any dynamic characteristic if a transducer is used to change the characteristic (frequency, temperature, velocity, etc.) into a voltage. One common application is frequency response measurements, where the Y axis corresponds to signal amplitude and the X axis corresponds to frequency.

1. Set the trigger **SOURCE** switch, the trigger **COUPLING** switch, the **VERT MODE** switch, and the **TIME/DIV** control all to their **X-Y** positions (**TIME/DIV** fully counterclockwise). In this mode, channel 1 becomes the X axis input and channel 2 becomes the Y axis input.

2. The X and Y positions are now adjusted using the horizontal ◄► **POS** and **CH 2** ▲▼ **POS** controls respectively.

3. Adjust the amount of vertical (Y axis) deflection with the **CH 2 VOLTS/DIV** and **VAR** controls.

4. Adjust the amount of horizontal (X axis) deflection with the **CH 1 VOLTS/DIV** and **VAR** controls.

EXTERNAL HORIZONTAL OPERATION

In the **EXT** Horizontal operating mode, an external signal can be connected to the **EXT TRIG** input to control the oscilloscope sweep.

1. Set the trigger **SOURCE** switch to the **EXT** position, the **VERT MODE** switch to the desired position (the **EXT** Horizontal mode can be used in single-trace, dual-trace, or add mode), and the **TIME/DIV** control to the **X-Y** position (fully counterclockwise). In this mode, the **EXT TRIG** input becomes the sweep signal.

2. The X and Y positions are now adjusted using the horizontal ◄► **POS** and ▲▼**POS** controls respectively.

3. Adjust the amount of vertical (Y axis) deflection with the appropriate **VOLTS/DIV** and **VAR** controls (**CH 1** for **CH 1 VERT MODE**, **CH 2** for **CH 2 VERT MODE**, or both **CH 1** and **CH 2** for **DUAL VERT MODE**).

4. The amount of horizontal (X axis) deflection is controlled by the amplitude of the signal applied to the **EXT TRIG** jack.

VIDEO SIGNAL OBSERVATION

Setting the trigger **COUPLING** switch to the **TV** position permits selection of vertical or horizontal sync pulses for sweep triggering when viewing composite video waveforms.

The **TV V** mode is automatically selected at sweep rates of 0.1 ms/div and slower. Vertical sync pulses are selected as trigger to permit viewing of vertical fields and frames of video. A sweep time of 2 ms/div is appropriate for viewing fields of video and 5 ms/div for complete frames (two interlaced fields) of video.

The **TV H** mode is automatically selected at sweep rates of 50 µs/div and slower. Horizontal sync pulses are selected as trigger to permit viewing of horizontal lines of video. A sweep time of about 10 µs/div is appropriate

for displaying lines of video. The **SWEEP/VAR** control can be set to display the exact number of waveforms desired.

At most points of measurement, a composite video signal is of the (-) polarity, that is, the sync pulses are negative and the video is positive. In this case, use **(-) SLOPE.** If the waveform is taken at a circuit point where the video waveform is inverted, the sync pulses are positive and the video is negative. In this case, use **(+) SLOPE.**

OSCILLOSCOPE APPLICATIONS

Applications Guidebook

B & K-Precision offers a "Guidebook to Oscilloscopes" which describes numerous applications for this instrument and important considerations about probes. It also includes a glossary of oscilloscope terminology and an understanding of how oscilloscopes operate. It may be obtained free of charge by filling out and mailing the postage-free coupon card enclosed with this instrument.

WARNING

The following instructions are for use by qualified service personnel only. To avoid electrical shock, do not perform any servicing other than contained in the operating instructions unless you are qualified to do so.

High voltage up to 12,000 volts is present when covers are removed and the unit is operating. Remember that high voltage may be retained indefinitely on high voltage capacitors. Also remember that ac line voltage is present on line voltage input circuits any time the instrument is plugged into an ac outlet, even if turned off. Unplug the oscilloscope and discharge high voltage capacitors before performing service procedures.

FUSE REPLACEMENT

If the fuse blows, the pilot light will go out and the oscilloscope will not operate. The fuse should not normally open unless a problem has developed in the unit. Try to determine and correct the cause of the blown fuse, then replace only with the correct value fuse. For 100 V or 120 V operation, use a 0.5 A, 250 V, 5x20 mm slow-blow fuse (B & K part number 198-300-0-500). For 220 V, 230 V, or 240 V operation, use a 0.3 A, 250 V, 5x20 mm slow-blow fuse (B & K part number 198-300-0-300). The fuse is located on the rear panel adjacent to the power cord receptacle.

Remove the fuseholder assembly as follows:

1. Unplug the power cord from rear of scope.
2. Insert a small screwdriver in fuseholder slot (located between fuseholder and receptacle). Pry fuseholder away from receptacle.
3. When reinstalling fuseholder, be sure that the fuse is installed so that the correct line voltage is selected (see LINE VOLTAGE SELECTION).

LINE VOLTAGE SELECTION

To select the desired line voltage, simply insert the fuse and fuse holder so that the appropriate voltage is at the top (pointed to by the arrow). Be sure to use the proper value fuse (see label on rear panel).

PERIODIC ADJUSTMENTS

Screwdriver adjustments only need to be checked and adjusted periodically. Probe compensation, and trace rotation are included in this category. Procedures are given below.

Probe Compensation

1. Connect probes to **CH 1 (X)** and **CH 2 (Y)** input jacks. Repeat procedure for each probe.
2. Touch tip of probe to **CAL** terminal.
3. Adjust oscilloscope controls to display 3 or 4 cycles of **CAL** square wave at 5 or 6 divisions amplitude.

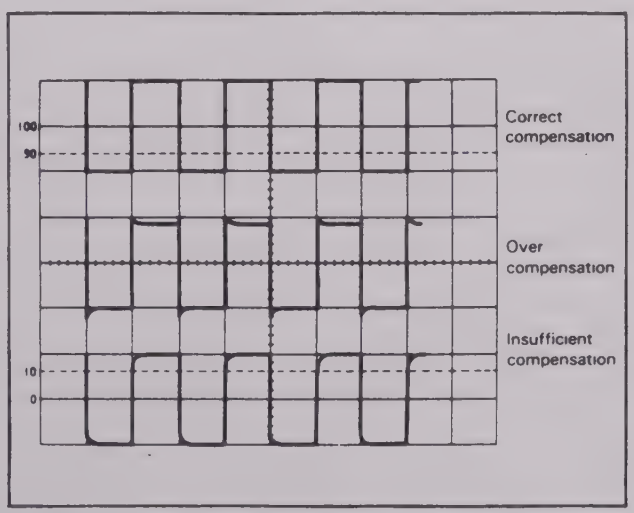


Fig. 6. Probe Compensation Adjustment.

4. Adjust compensation trimmer on probe for optimum square wave (minimum overshoot, rounding off, and tilt). Refer to Fig. 6.

Trace Rotation Adjustment

1. Set oscilloscope controls for a single trace display in **CH 1** mode, and with the channel 1 **AC-GND-DC** switch set to **GND.**

2. Use the channel 1 ▲▼ **POS** control to position the trace over the center horizontal line on the graticule scale. The trace should be exactly parallel with the horizontal line.

3. Use the **TRACE ROTATION** adjustment on the front panel to eliminate any trace tilt.

CALIBRATION CHECK

A general check of calibration accuracy may be made by displaying the output of the **CAL** terminal on the screen. This terminal provides a square wave of 2.0 V p-p. This signal should produce a displayed waveform amplitude of four divisions at 0.5 V/div sensitivity for both channel 1 and 2 (with probes set for direct). With probes set for 10:1, there should be four divisions amplitude at 50 mV/div sensitivity. The volts/div and **SWEEP/VAR** controls must be set to **CAL** during this check.

The CAL signal may be used only as a general check of calibration accuracy, not as a signal source for performing recalibration adjustments; a signal source of ± 0.3% or better accuracy is required for calibration adjustments.

INSTRUMENT REPAIR SERVICE

Because of the specialized skills and test equipment required for instrument repair and calibration, many customers prefer to rely upon **B & K-Precision** for this service. We maintain a network of **B & K-Precision** authorized service agencies for this purpose. To use this service, even if the oscilloscope is no longer under warranty, follow the instructions given in the WARRANTY SERVICE INSTRUCTION portion of this manual. There is a nominal charge for instruments out of warranty.

WARRANTY SERVICE INSTRUCTIONS
(For U.S.A. and its Overseas Territories)

1. Refer to the MAINTENANCE section of your **B & K-Precision** instruction manual for adjustments that may be applicable.

2. If the above-mentioned does not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred in U.S.A.) to the nearest **B & K-Precision** authorized service agency (see list enclosed with unit).

If your list of authorized **B & K-Precision** service agencies has been misplaced, contact your distributor for the name of your nearest service agency, or write to:

B & K-Precision, Factory Service Operations
Maxtec International Corporation
6470 West Cortland Street
Chicago, Illinois 60635
Tel (312) 889-1448

Also use this address for technical inquiries
and replacement parts orders.

LIMITED THREE-YEAR WARRANTY

MAXTEC INTERNATIONAL CORPORATION warrants to the original purchaser that its **B & K-Precision** product, and the component parts thereof, will be free from defects in workmanship and materials for a period of three years from the date of purchase.

MAXTEC will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized **B & K-Precision** service contractor or the factory service department, accompanied by proof of the purchase date in the form of a sales receipt.

To obtain warranty coverage in the U.S.A., this product must be registered by completing and mailing the enclosed warranty registration card to MAXTEC, **B & K-Precision**, 6470 West Cortland Street, Chicago, Illinois 60635 within fifteen (15) days from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

MAXTEC shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

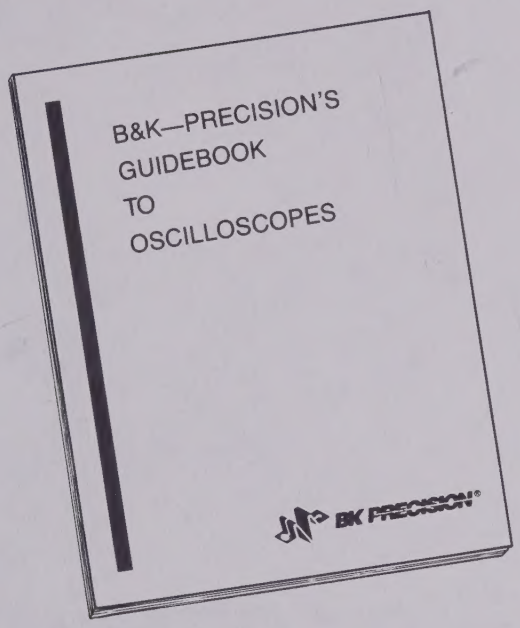
This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your **B & K-Precision** distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to **B & K-Precision** Service Department, 6470 West Cortland Street, Chicago, Illinois 60635, properly packaged to avoid damage in shipment.

B & K-Precision Test Instruments warrants products sold only in the U.S.A. and its overseas territories. In other countries, each distributor warrants the **B & K-Precision** products which it sells.

FREE

OSCILLOSCOPE APPLICATIONS MANUAL



A copy of the "B & K-Precision's Guidebook To Oscilloscopes" Applications Manual is offered FREE to purchasers of B & K-Precision Oscilloscopes

CONTAINS:

- Numerous Application Examples Showing How To Gain The Most From Your Scope's Features And Capabilities.
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